Disclosure

• Consultant: DaVita
Glucose sparing regimens

- Non-glucose containing solutions
- Minimize higher glucose containing fluids
- Incremental PD prescriptions
- Provide appropriate dialysis dose (Kt)
- Diuretics
- Sodium restricted diet
What V in Kt/V?

Short Answer:

I don’t know but will try to explain why.
Peritoneal Dialysis

\[
\frac{Kt}{V} = \frac{(D/P_{\text{urea}})(\text{Dialysate drain volume})}{V_D\text{Urea (TBW)}}
\]

How do you increase Kt/V?
- Focus on Kt or the dialysis dose
- We can increase Kt by increasing percent saturation of dialysate volume or increasing dialysate volume.

But how accurate is determination of “V_DUrea”? Why do we normalize dose for “V_DUrea”??
Peritoneal Dialysis Solute Clearance Target (recommendations)

“2.6 When calculating Kt/Vurea, one should estimate V from either the Watson or Hume equation in adults. In the absence of evidence, use of the patients’ ideal or standard (rather than actual) weight should be considered in the calculation of V.”

“For the patient close to or at dry eight the Watson or Hume equation is acceptable. In the underweight patients, it also seems sensible to adjust clearance for ideal body weight.”

In amputees...... adjust for amputations using normograms

“However, the correct determination of V for the overweight patients is unclear. The Watson formula overestimates TBW in the obese patient and underestimates it in overhydrated patients.”

(Our dialysis provider uses actual weight)

What is the impact of “V” overestimation in obese patients?

• Kt, or dialysis dose, must be higher to achieve target Kt/V
• If Kt is higher then amount of dialysate fluid will likely be higher
• If amount of dialysate fluid is higher then glucose exposure will be higher
Case

- 50 year old, industrious yet sedentary, male dialysis patient weighs 79.5 kg and is 70 inches tall.
- No residual renal function.
- Kt/V =1.8 and he is doing extremely well.
  - Albumin 4.1
  - Sense of well being is excellent
- He starts an organic doughnut company that goes out of business in 6 months because he ate the potential profits and in the process gained 10 kg.
- Without a change in dialysis prescription he fails Kt/V.
- Why?
Case (con’t)

• Before he ate the doughnuts, at a weight of 79.5 kg, TBW (Watson) = 43.7 L.

• $Kt/V = 1.8; \quad Kt = (1.8)(43.7) = 78.7 \text{ L}.$

• At weight of 89.5 kg TBW (Watson) = 47.1 L.

• Without change in prescription or dialysis dose, Kt is unchanged (78.7)

• Now $Kt/V = 78.7/47.1 = 1.67$

• He still feels great

• Albumin level still 4.1
Case (con’t)

• Is he not well dialyzed now?
• Did 10 kg doughnut induced weight gain turn into lean body mass or FAT?
• Does fat increase total body water?
• Should we use actual weight, ideal (standard) weight or adjusted weight (an intermediate between ideal and actual weight that assumes a fixed percentage of the difference between the actual and ideal body weight is attributable to fat-free mass)?
• Should we normalize Kt differently?
Determination of V: Formula of Watson

ABSTRACT Individual total body water volumes for 458 adult males and 265 adult females obtained from dilution studies, together with their height, weight, and age have been selected from the literature. These values were used to derive total body water prediction equations for adults of any age. The equations that gave the best fit were for males:

- Data derived from 30 different studies
- Dilution technique
- Mostly healthy volunteers
- Some “minor illnesses”
- No edema
- Did not include dialysis patients
- Included data from Hume

some studies (18, 21, 24) heights were not given but they could be recalculated from surface area figures using the DuBois equation (38) if weights were reported. Where
Determination of $V$: Formula of Hume

- 30 male and 30 female normohydrated patients
- Patients: Convalescing from myocardial infarction, CVA, acute bronchitis, peptic ulcer, anxiety state, undiagnosed abdominal pain, disseminated sclerosis, primary obesity, osteoarthritis.
- NO dialysis patients.
- “None had clinical evidence of fluid retention or malnutrition, conditions known to influence the relationship between total body water and total body weight.”

TBW by Watson and tritiated water dilution.

Watson overestimates low volume and underestimates large volumes

Watson overestimates V in obesity

Watson underestimates V in volume expanded (overhydrated) patients

Do we need to know true Kt/V or just a measured Kt/V (even if flawed) that predicts outcomes?
Do we need to know true Kt/V or just a measured Kt/V that predicts outcomes?

- Two RCT studies examined different Kt/V doses and outcomes:
  - Hong Kong (Lo, et al Kidney Int 64:, 649-656, 2003)

- Does the methodology (calculation of “V”) and study population help answer this question?
Weight and obesity in RCT’s and US population.

<table>
<thead>
<tr>
<th>Method of “V”</th>
<th>ADEMELEX</th>
<th>Lo, et al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watson</td>
<td>Watson</td>
<td>Watson</td>
</tr>
<tr>
<td>Weight used for calculation</td>
<td>Not stated</td>
<td>“crude” weight</td>
</tr>
<tr>
<td>Patients: Range of weights</td>
<td>~ 66 ± 13 kg</td>
<td>~ 56 ± 10 kg</td>
</tr>
<tr>
<td>Patients: Range of BMI</td>
<td>Not stated</td>
<td>~ 22 ± 3</td>
</tr>
<tr>
<td>Patients: Range of BSA</td>
<td>~ 1.7 ± 0.2</td>
<td>Not stated</td>
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</table>

United States Renal Data System, 2014 annual data report

<table>
<thead>
<tr>
<th>USRDS</th>
<th>Mean weight (kg)</th>
<th>Mean BMI</th>
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<tbody>
<tr>
<td>2004-2006</td>
<td>79.7</td>
<td>29</td>
</tr>
<tr>
<td>2007-2009</td>
<td>82.2</td>
<td>30.8</td>
</tr>
<tr>
<td>2010-2012</td>
<td>83.8</td>
<td>31.6</td>
</tr>
</tbody>
</table>
Conclusions: Kt/V measurement in RCT and outcomes

- Though Ademex and Hong Kong RCT’s use Watson to calculate “V”, but we do not know which weight (ideal or actual).
- The measured Kt/V in these two studies might be reasonably accurate because of low prevalence of obesity. Study population actual weight was probably close to ideal weight.
- The study population is not similar to average US population and probably does not include the same degree and frequency of obesity in this country.
- Obesity decreases accuracy of “V” and therefore the accuracy of Kt/V. The results of these studies do not necessarily predict outcome in US patients. We don’t know what weight to use in obese patient.
- We don’t know if an accurate “V” to measure Kt/V might predict outcomes.
Do we have studies that examine usefulness of different weights to normalize V?

• Fried J, et al
  – Retrospective observational study 1432 anuric PD patients 1/1994 – 1/21/2005
  – Association of dialysis dose with mortality and time to first hospitalization.
  – Calculated “V” using actual or ideal weight
  – Limitations
    • Not randomized
    • Few malnourished patients
    • included CAPD and CCPD

1) Kt/V using actual weight associated with mortality and hospitalization
2) Kt/V using ideal weight NOT associated with mortality and hospitalization

<table>
<thead>
<tr>
<th></th>
<th>Kt/V &lt;1.7 (N=293)</th>
<th>Kt/V 1.7-2.0 (N=366)</th>
<th>Kt/V&gt;2.0 (N=769)</th>
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<tbody>
<tr>
<td>Weight (kg)</td>
<td>88.2</td>
<td>83.6</td>
<td>74.2</td>
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<td>Ideal Weight (kg)</td>
<td>66.4</td>
<td>63.5</td>
<td>59.9</td>
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<tr>
<td>BMI kg/m²</td>
<td>29.6</td>
<td>28.9</td>
<td>27</td>
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<tr>
<td>BMI &lt;18.5 (%)</td>
<td>1.1</td>
<td>1.4</td>
<td>2.8</td>
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<tr>
<td>BMI 19-24.9 (%)</td>
<td>26.1</td>
<td>29.2</td>
<td>42.0</td>
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<td>BMI 25-29.9 (%)</td>
<td>31.7</td>
<td>31.5</td>
<td>31.3</td>
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<td>BMI 30-34.9 (%)</td>
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<td>22.0</td>
<td>13.9</td>
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<td>BMI 35-39.9 (%)</td>
<td>10.2</td>
<td>9.7</td>
<td>3.8</td>
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<td>BMI&gt;40 (%)</td>
<td>6.7</td>
<td>6.1</td>
<td>6.4</td>
</tr>
<tr>
<td>Kt (L)</td>
<td>63.7</td>
<td>75.8</td>
<td>90.3</td>
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Are there other methods to more accurately measure V?

- **Bioimpedance Spectroscopy (BIS)**
  - Low-intensity multifrequency alternating current flow through patient’s body
  - Determines hydration and nutritional status

Are there other methods to more accurately measure $V$?

• Though Bioimpedance Spectroscopy is a more accurate measurement of hydration there are no outcome studies using this methodology
Should we normalize dialysis dose (Kt) for “V” (TBW) or something else?

• Goal: normalize Kt for body mass producing uremic toxins
• Fat mass and muscle mass are unlikely source of uremic toxins. “V” was felt to be a measure of lean body mass and not fat mass.
• Visceral cell mass (VCM) is the most likely source of uremic toxins; should normalize for VCM.
• VCM correlates more with BSA than weight or “V”.
• VCM is BSA scales to body mass to the 2/3 power whereas “V” is directly proportional to body mass. At lower body mass VCM is a higher fraction of body mass.
Does normalization by BSA correlate with outcomes?

• In HEMO study increasing dose appeared to improve survival in women but not in men.
• Surface Area normalization (SAn) of Kt/V measurement demonstrates that women with low body weight tend to receive a lower dose of dialysis than men despite similar Kt/V.
• When normalized to SA there is a progressive improvement in outcome in women as Kt increases.
Dialysis dose in women is lower when normalized for BSA and not V

Women high dose equivalent to men conventional dose.

Women at conventional dose were underdialyzed

Conclusions

• Watson “V” is not accurate.
• There is no outcome data for Kt/V using ideal body weight in obese patients.
• V by bioimpedance may be good measure of V but there is no outcome data.
• Body surface area may be best term for normalization of dialysis dose in HD and possibly PD patients (no outcome data).
• Need studies to examine other options for normalizing dialysis dose in PD.
Questions?